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DEVELOPMENT OF A MINIATURE HAND GENERATOR

Task 6

FINAL REPORT

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FINAL REPORT

Project 3027 Task 6

Development of a Miniature Hand Generator

I Scope

The objective of Task 6 was fourfold as follows:

1. To fabricate a complete and tested prototype model of the HG-1 hand generator.

2. To produce a complete set of production drawings including bills of material for the HG-1 hand generator.

3. To fabricate a complete and tested prototype model of the HG-3 hand generator.

4. To produce a complete set of production drawings including bills of material for the HG-3 hand generator.

II Hand Generator HG-1

1. Prototype Model - The major portion of the time and effort under Task 6 was spent in attempting to develop a practical version of the hydraulic speed changer previously devised for this type of hand generator. The allotment was made in this manner because of the greater saving in weight and volume promised by such a unit. A description of the work performed has been set forth in the bi-monthly Progress Reports on the task and more particularly in Interim Report No. 3, covering the months of November and December 1953.

As a result of tests of several modifications of the original designs, the conclusion was reached that the hydraulic speed changer would

require considerable further basic development before it could be made practical for use in its intended application. It was demonstrated that the required minimum efficiency of 85% could not be achieved without basic re-design. The low efficiency of the system was due primarily to certain fixed dynamic losses in the motor which were excessive when compared to the small power output at the high rated speed.

Despite the failure to develop a practical hydraulic system for this particular application, the studies during this period showed that the motor, as presently designed, can be considered practical for use under any one of the following conditions:

a. Where efficiency requirements may be relaxed to permit use of a motor with about 50% efficiency.

b. Where for the same speed (5450 RPM maximum) and high efficiency requirement, the output power could be raised to about 1/4 horsepower. Higher output could be obtained by increasing the axial length of the motor while holding the diameter and pressure the same, or by retaining the present dimensions and raising the operating pressure.

c. Where for the same output, .15 horsepower, the speed requirement would be about 2500 RPM maximum, also employing higher pressure.

The conclusions discussed above were reached at the beginning of December 1953. Accordingly, after conferring with liaison engineers of the contracting agency, the emphasis of the task was removed from the hydraulic device and placed on the HG-3, gear-driven model. As a result, a complete, assembled model of the HG-1 unit is not available for delivery, as originally planned. The important components, unassembled, are to be delivered.

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2. Production Drawings - During the time when work was being performed on the HG-1 hand generator, production drawings for this unit were drafted. The procedure followed was to make up the detail drawings in accordance with the design of the piece at the time of drafting and then to make corrections to conform to modifications found necessary during fabrication or testing of the unit. As a result of this procedure, the set of production drawings were substantially complete by the time it was concluded that such a unit would be impractical. At that point, all further effort toward completing the production drawings was abandoned in favor of devoting the remaining time to completing the production drawings of the HG-3 model.

III Hand Generator HG-3

1. Prototype Model -

a. Description - In accordance with the original intent of Task 6, the hand generator Model HG-3, employing a planetary gear speed-changer and a hollow-shaft generator, was completed. The result of this effort is a practical and efficient unit which, while not realizing as much saving in weight and volume as was hoped for in the HG-1 Model, is still a substantial improvement in this respect over the GN-58A. Included in Appendix A to this report are photographs of this unit, taken in the assembled and "knocked down" conditions.

Reference is made to Appendix B of this report for Tables I and II which give the weight and volume of this model and the comparative corresponding figures for the GN-58A. Included in Table I is an additional set of weights for the production unit of the HG-3. These indicate that it will be almost three quarters of a pound light than the engineering prototype.

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The increased savings in weight was made possible through further modifications found to be practical during fabrication of the existing prototype. A list of these modifications and the resulting weight saving of each is given in Appendix B, Table III.

b. Limitations - Although the hand fabricated engineering prototype model is an adequately constructed unit for demonstrative and laboratory test purposes, it has certain undesirable features which would not be present in the production item. These limitations result from the pressure of time and funds and compromises that had to be made in hand fabricating the prototype. Appendix C contains a list of these features and statements as to how they would be corrected in production. Also included in this appendix is a detailed list of the differences in construction between the experimental and production units.

c. Performance Characteristics - Unfortunately, limitations of time have prevented conducting detailed laboratory tests which would give such firm figures on performance as mechanical and electrical efficiency, voltage regulation, filtering, acoustical noise value, etc. However, preliminary comparisons made between the HG-3 and GN-58A operating under the same conditions indicate that the first should be equal in quality to the second. It will be noted that the acoustical noise of the HG-3 is greater than that of the present service unit but it is believed that the installation of proper ball races in the speed-changer, dynamically balancing the generator armature and correctly "wearing-in" the brushes will remedy this deficiency.

d. Recommendations - Besides the improvements in construction between the engineering model and a production unit listed in Appendix C, experience gained in fabricating and testing the former indicated certain

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additional modifications that should be considered. Time would not permit incorporating them in the actual production drawings. These recommendations are submitted for consideration before the unit is put into production:

(1) The present system of shock mounting should be replaced by a molded sponge rubber "boot" which fits over the entire inner assembly. Resistance to turning would be secured by a boss cast as part of the end plate to engage a mating depression in the boot.

(2) The present knurled leg-clamps should be replaced with a stub wing form for easier tightening.

(3) The existing standard Signal Corps power receptacle should be replaced with a lighter and smaller waterproof, five-pin type such as the Cannon Electrical Development Company Type "W" or its equal.

(4) The present basic generator unit should be replaced with one that employs aluminum windings. Such a unit, according to liaison engineers of the contracting agency is already in an advanced stage of development. This substitution would further reduce the weight of the production HG-3 unit to 18 lbs.-7 oz. and realize a 32% saving over the GN-58A.

2. Production Drawings - Along with the engineering prototype model of the HG-3 hand generator, a set of production drawings have been completed, including all the changes outlined in Appendix C. The aim of these drawings has been not only to make the details of each piece amenable to standard production techniques but to suggest to the manufacturer the logical steps for assembly of the various component units.

3. Assembly and Disassembly Instructions - Appendix D contains the steps to be taken in disassembling the engineering prototype model.

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APPENDIX A

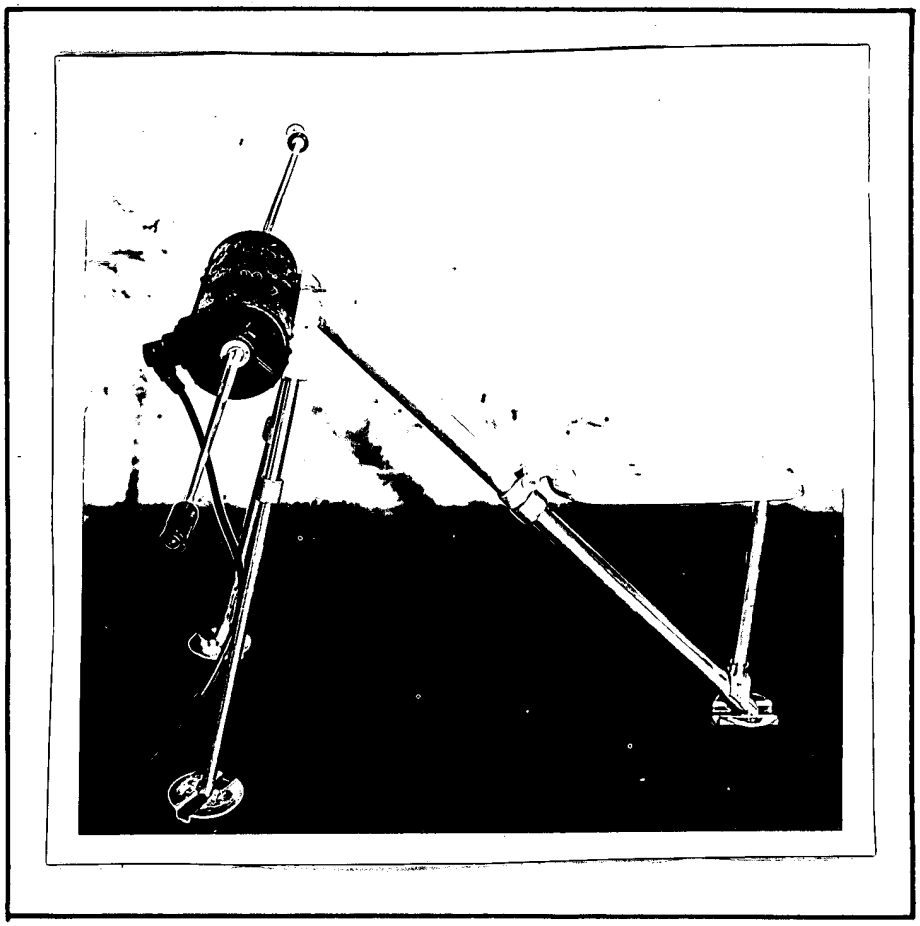

FIG. 1

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APPENDIX A

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FIG. 2

APPENDIX B

TABLE I

	HG-3		GN-58A
	Engineering Prototype	Production Unit	
Weight of Case	15 lbs.-15 oz.	15 lbs.- 5 oz.	23 lbs.- 0 oz.
Weight of Handles	14 oz.	14 oz.	14½ oz.
Weight of Stand	4 lbs.- 4 oz.	4 lbs.- 4 oz.	3 lbs.-13½ oz.*
TOTAL	21 lbs.- 1 oz.	20 lbs.- 7 oz.	27 lbs.-12 oz.
% Saving	25	27**	

*This is the weight of the lightest GN-58A stand. A second type weighs 6 pounds.

**Employment of aluminum generator windings would raise % Savings to 32%.

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APPENDIX B

TABLE II

	HG-3	GN-50A	% Saving
Method I	672 cu. in.	904 cu. in	25½
Method II	990 cu. in.	2382 cu. in.	58
Method III	784 cu. in.	1008 cu. in.	22

Due to the several definations that can be considered when speaking of the volume of the unit, the comparative figures are based on the following methods of computation:

METHOD I - The volume is considered to be the sum of the net volume of each component.

METHOD II - The volume is considered to be the volume of a cube defined by the over all dimensions of the unit considered as one package.

METHOD III - The volume is considered to be the approximate volume occupied by the unit considered as one package, in which the contour of the package has been considered.

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APPENDIX B

TABLE III

Description of Differences in Construction	Weight: Engineering Prototype	Weight: Production Unit
Crank Socket Bearings - Nylon is substituted in the production unit for bronze in the engineering prototype.	2.8 oz.	1.0 oz.
Crank Socket - Aluminum alloy is substituted in the production unit for stainless steel in the engineering prototype.	5.0 oz.	1.5 oz.
1st Stage Input Plate - Speed Changer - Lightening holes in the web are provided for in the production unit.	1.0 oz.	-
Sun Gear 2nd Stage - Speed Changer - Aluminum alloy is substituted in the production unit for stainless steel in the engineering prototype.	3.6 oz.	1.3 oz.
Sun Gear 3rd Stage - Speed Changer - Aluminum alloy is substituted in the production unit for stainless steel in the engineering prototype.	2.4 oz.	.9 oz.
	14.8 oz.	4.7 oz.
	4.7 oz.	
Saving in Weight	10.1 oz.	

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APPENDIX C

Limitations present in the engineering prototype that would not be characteristic of the production unit -

1. Excessive acoustic noise is present during operation. This is the result of poor surface conditions of the ball races in the speed changer. This condition is the result of dimensional errors in fabrication and inadequate hardness of the race material. The production unit will have bearing race inserts with a 60 RC hardness as compared to the 45 RC hardness of the engineering prototype.

2. There is present additional drag and resulting decrease in mechanical efficiency due to the poor condition of the ball races in the speed changer and dimensional errors in original assembly of the unit. This permits the rotating elements to sag slightly, thus increasing the loss in the gears. This is corrected in the production unit by adequate hardness of the ball races which will permit slight pre-loading of the thrust bearing and more positive positioning of the rotating parts.

3. There is present an undesirable vibration due to the sag rotating parts in the speed changer, and to an unbalance in the generator armature. The first will be corrected as described above and the second by standard production dynamic balancing procedures.

4. There is present a certain amount of acoustical and electrical noise due to inadequate brush contact. This is automatically self-correcting with use, and it will be prevented in production by standard run-in techniques.

5. There is a tendency for the welded joints in the stand to crack open due to movement of the stand during operation. This is because these joints, of necessity, have been made with #194 Eutecrod, a type of aluminum brazing rod instead of by heliarc welding as will be the case with the production unit.

6. The strength of the stand is below the design level because the tubing is of 24S-T4 and 61S-T6. The production unit tubing will be of 75S-T6 aluminum alloy which was unavailable at the time of fabrication of the engineering prototype.

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APPENDIX C

Differences in contruction between the production unit and the engineering prototype -

PRODUCTION UNIT	ENGINEERING PROTOTYPE
1. Speed changer planetary gear shafts	
(a) All shafts provided with axial and radial lubricating.	(a) No provision for direct lubrication between gear and shaft.
2. Speed changer 1st stage Sun gear - Bearing races to be inserted in gear.	Bearing races are integral with gear.
3. Speed changer - input plate	
(a) Bearing races to be inserted in plate.	(a) Bearing races are integral with plate.
(b) Coupling housing to be integral with plate	(b) Coupling housing is keyed to plate.
(c) Lightening holes provided in plate.	(c) No lightening holes.
4. Speed changer gears - Back lash tolerance to be double that of engineering model.	
5. Speed changer planetary gears - 2nd and 3rd stages to be molded.	Gears are machined.
6. Speed changer - fixed gears - 2nd and 3rd stages to be of 75S-T6 aluminum.	Now of 24S-T4 aluminum.
7. Speed changer thrust ball races - to be of SAE 51440F hardened to 60 RC.	Now of SAE 4130 hardened to 45 RC.
8. Speed changer 2nd stage Sun gear	
(a) Bearing races to be inserted in gear.	(a) Bearing races are integral with gear.
(b) Material to be of 75S-T6 aluminum.	(b) Material is of SAE-4130.
9. Speed changer - 3rd stage Sun gear	
(a) Bearing races to be inserted in gear.	(a) Bearing races are integral with gear.
(b) Material to be 75S-T6 aluminum.	(b) Material is of SAE-4130.

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APPENDIX C

Differences in construction between the production unit and the engineering prototype - CONTINUED -

PRODUCTION UNIT	ENGINEERING PROTOTYPE
10. Speed changer assembly	
(a) To be held together with Allen hd. screws. (b) To be doweled with steel pins.	(a) Held together with Round hd. screws. (b) Doweled with steel pin with nuts on each end.
11. Crank sockets	
(a) Both to be cast. (b) Both made from 355S-T6 aluminum.	(a) Machined. (b) 416 stainless steel.
12. Crank socket bearings - to be made of molded nylon.	Now machined from bearing bronze.
13. Crank socket thrust washer - to be made of molded nylon.	No such piece.
14. Power plug housing cover	
(a) To be cast of 355S-T6 aluminum. (b) To screw on plug threads (c) To be secured by a bead chain.	(a) Machined of 24S-T4 aluminum. (b) Screws in threads in housing. (c) Not secured.
15. Case end plate - to be cast of 355S-T6 aluminum.	Machined from 24S-T4 aluminum.
16. Case cover - to be cast of 355S-T6 aluminum.	Machined from 24S-T4 aluminum.
17. Generator case - to be seamless drawn aluminum tubing.	Rolled aluminum sheet welded longitudinally.
18. Stand legs - material to be 75S-T6 aluminum alloy.	Material now 24S-T4 aluminum alloy.
19. Welding - joints to be heliarc welded.	Joints now made with 194 Eutecrod.
20. Seat stiffener - to be of 1/2" wide x 1/16" thick 61S-T6 aluminum strip welded to seat.	Now of 1/2" x 1/2" x 3/32" aluminum angle screwed to seat.

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APPENDIX C

Difference in construction between the production unit and the engineering prototype - CONTINUED -

PRODUCTION UNIT	ENGINEERING PROTOTYPE
21. Leg hinge pins - to be attached directly to mudshoes by welding.	Attached by welding brackets to mudshoes.
22. All hinge pins - to be Rollpins.	Straight steel pins with 1/8" I.D.
23. Speed changer - cover 3rd stage end. Ball bearing to be radial-thrust type.	Ball bearing now radial type.
24. Speed changer - all Sun and fixed gears. Provisions made to have .010" greater face width than planetary gears.	Face width of all gears are the same.
25. Speed changer - planetary gear shaft 3rd stage - to be secured by nuts to 2nd stage Sun gear.	Secured to 2nd stage Sun gear by staking end of shaft.
26. Crank socket bearings -	
(a) To be provided with screw driver slot for removal.	(a) Provided with holes for removal with pin wrench.
(b) To be locked in housing with set screw.	(b) No provision for positive locking in housing.
27. Voltage regulator - to be provided with a holding down strap.	No provision for holding down strap.
28. All aluminum pieces except tubular sections of stand and speed changer gears - to be of 61S-T6 aluminum alloy.	Now of various alloys.
29. Stand-all lower leg section. Holes for retaining chain pins to be recessed to prevent interference with sliding into upper sections.	Pins are now ground off flush with outside surface of leg section.
30. Stand - case support plate. Brace to be welded to back leg will be integral with plate.	Brace now separate and welded to both leg and support plate.
31. Stand - mudshoes - to be formed from circular blank.	Mudshoes are now circular after forming.
32. Stand - toggle pin lever - handle section to be riveted to toggle section.	Handle section screwed to toggle section.

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APPENDIX D

DISASSEMBLY PROCEDURE

1. Unscrew cover screws and remove cover. The resistance of this piece to removal is due only to the presence of an O-ring seal.

2. Withdraw crank shaft from clearance hole at center of unit.

3. Unscrew power plug housing screws and pull housing out until back connections are exposed. Unsolder wire leads.

4. Remove all shock mount holding screws. Care should be taken not to lose either the O-ring or washer of the "Lock-O-Seals".

5. Remove crank socket bearing and crank socket from cover and case end plate. Special pin wrench has been provided for this purpose.

6. Slide internal unit out of case with assistance of a 3/4" diameter rod pushing against speed changer through socket bearing housing hole at covered end. Reasonable care should be taken that shock mounts are not injured as they traverse the power plug opening or that output wires are not torn or pinched as the electrical component section leaves the case.

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APPENDIX D

ASSEMBLY PROCEDURE

1. Slide entire assembly into case with the speed changer end first. Inner assembly should be oriented angularly so that the cut away section in inner electrical component plate falls at the same point as the power plug housing opening. The shock mounts on the inner end of the speed changer fall into cut away sections in end plate. The shock mounts may be tilted enough to free them if they interfere with the edge of the case mouth.

2. Engage end plate crank socket with matching square in speed changer and screw end plate socket bearing into housing.

3. Screw in shock mount screws. Final tightening should be done in rotation with all screws in place. Shock mounts may be moved about enough to match up holes with case.

4. Slide in crank shaft. End with longest square engages square in end plate crank socket.

5. Put on cover and screw in cover screws. Final tightening should be done in rotation when all screws are in place. Some lubricant on O-ring will ease pushing cover home.

6. Engage cover crank socket with crank shaft and screw cover socket bearing in housing.

7. Solder output leads to proper pins in back of power plug.

8. Push power plug housing in place and screw in screws. Reasonable care should be taken that the output leads lay in the case so as not to damage the wire or the filter circuit components.

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APPENDIX D

PRECAUTIONARY NOTES

1. If the unit is operated outside of case, care should be exercised that the input plate of the speed changer is not subject to radial loads. The use of some type of intermediate bearing between input plate and power shaft is recommended.

2. If the unit is operated outside the case in a horizontal position, the main support and torque resisting clamps should be at the speed changer. Supports should also be given to the generator to prevent destroying the alignment between it and the speed changer.

3. The best method of storing the internal section outside of the case is vertically and resting on the speed changer shock mounts.

4. Care should be taken to prevent foreign material from entering speed changer through the hollow center of the unit.

5. Reasonable care should be taken not to damage regulator resistor panel on outer electrical support plate.

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CONTRACT NO. XG-578, Task 6 TOTAL ESTIMATED EXPENDITURES $46,100.

VOUCHER NO.	PERIOD COVERED	AMOUNT	TOTAL
	Date of initiation to July 31, 1953	$2,309.17	$2,309.17
	July 31 to Aug. 31	7,438.72	9742.89
	~~Sept to Sept~~ 1 Sept to 30 Sept 53	7,126.98	16869.37
	oct 1953	10,375.53	27244.90
	nov. 1 to Nov. 30, 1953	8,398.01	35,642.91

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